Collaborative Scheduling Using JMS in a Mixed Java and .NET Environment

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Overview

• A proof-of-concept prototype successfully demonstrated a collaborative scheduling solution for future NSAS Deep Space Network application

• A prototype distributed computing environment was established for collaborative scheduling

• Java Message Service (JMS) was used in a mixed Java and .NET environment for messaging
Agenda

• NASA Deep Space Network scheduling
• Collaborative scheduling concept
• Distributed computing environment
• Platform concerns in a distributed environment
• Messaging and data synchronization
• The prototype
• Conclusion
**Scheduling** is to arrange antenna times for space flight missions and ground-based science observations (requirements) under certain restrictions (constraints).

**Requirement:**
- N tracks every M days,
- Complex pattern-based coverage,
- Antenna arraying,
- Multiple Spacecraft Per Antenna, …

**Constraint:**
- Ground assets: Antenna, Equipment, Downtimes, …
- Mission: Viewperiod, Horizon mask, Setup/teardown, …
- Combined: BOT, RFI, …
DSN Scheduling Users

• DSN schedulers:
  – Schedule owner
  – Prepare maintenance schedule
  – Coordination

• Space flight project schedulers:
  – Provide requirements
  – Negotiation and proposals
  – Submit changes

• Station operators:
  – Carry out schedule
  – Handle contingency and anomalies
Current Scheduling System

- Mainly a manual process with software support
- Long-range, mid-range, near-real-time processes handled by different groups
- Various tools are deployed for each process
- Meetings to resolve conflicts
Future Scheduling System

- Seamless scheduling for all planning horizons
- A master schedule always exists, visible to all users
- Requirements and schedules are fully traceable
- Conflicts are resolved at the lowest level possible in a peer-to-peer fashion
- Meetings are called only as needed
- Workspace is provided to users to develop requirements and for what-if analysis
- Distinguish global (shared) workspace and local (private) workspace
- Private workspace may span a set of peers
- Need scalability (loading, # users, # assets) and extensibility (evolving technology)
- Intelligent assistants for decision support
Collaborative Scheduling Concept

- Decision Makers (DM): DSN schedulers, project schedulers, managers, operators, …
- Every one knows their specific requirements and constraints
- No single DM makes decisions for others (distributed decision making)
- DMs share information
- Shared responsibility to create a successful schedule
- Work as a team to resolve conflicts
Collaborative Scheduling Prototype Features

- Single master schedule shared by all users
- Conflict-aware scheduling
- Dynamic workspace/static workspace
- Private workspace with limited sharing
- Scenario management for comparison
- Synchronous/Asynchronous collaboration (e.g. conflict resolution, negotiation)
- Ownership and workflow management
- Data synchronization
- Messaging/notification/alert
- Intelligent assistant
- Traceability
- Distributed computing environment
Distributed Computing Environment

• **Objective:** To connect users and resources in a transparent, open, and scalable manner.
  
  – **Transparency:** distributed experts are working together as if they are co-located

  – **Openness:** provides each project with a continually open environment that enables interaction with other projects until a satisfactory condition exists.

  – **Scalability:** The solution should be able to accommodate changes in the number of user projects and ground resources in the DSN domain.
Architecture

- Data
- Data access
- Legacy information
- Business logic
- Web services
- Messaging
- Client interfaces
Platform concerns in a distributed environment

- Distributed computing environment should be open and flexible for multiple frameworks.
- JAVA and .NET are two major players now:
  - It is expected that they will reach a 50-50 market share by the end of this year (based on articles from Gartner, Meta group, ZDNet, ...). Each will probably share 30%-40% market.
  - Java: large-scale enterprise, multi-platform
  - .NET: small/mid-size development, easy to use, performance/speed advantage
- There may be other frameworks emerging in the future
- Take advantage of each framework based on our needs
Possible Cross-Platform Solutions

- Java: through virtual machines for many platforms
- .NET and Mono: provides the necessary software to develop and run .NET client and server applications on Linux, Solaris, Mac OS X, Windows, and Unix.
- Mainsoft: .NET to J2EE
- Others such as Qt (Trolltech)
Messaging & Data Synchronization

- Collaboration requires instant communication
- All users are notified in real-time regarding data changes
- JMS is used for centralized messaging
- Time synchronization is the base for data synchronization
- Keep messages in messaging bus and keep data in data bus
Prototype Implementation

- Use SOAP/XML-based Web services
- Agents and backend are implemented using .NET
- Web services are in ASP.NET
- Clients are in Java and .NET
- JMS for messaging
- IKVM is used for .NET to communicate with JMS
IKVM

• IKVM.NET is an implementation of Java for Mono and the Microsoft .NET Framework.

• It includes
  – a Java Virtual Machine implemented in .NET
  – a .NET implementation of the Java class libraries and
  – tools that enable Java and .NET interoperability.

• Using IKVM, we can take advantages from both Java and .NET
The Prototype

• Database
  – Master schedule
  – Dynamic workspace/static workspace
  – Time-based ownership
  – Traceability information

• Middle-tier
  – Conflict-aware scheduling
  – Private workspace sharing
  – Scenario management for comparison
  – Synchronous/Asynchronous collaboration (e.g. conflict resolution & negotiation)
  – Workflow management
  – Data synchronization
  – Notification/alert

• Web services wrapper

• Clients
  – Java client for schedule viewing with dynamic update under user’s control
  – .NET Integrated Analysis Environment for complete analysis experience
  – Web pages to view schedule
Java Client
.NET Integrated Analysis Environment
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How this works

1. Proposal
2. Share with B*
3. Sync
4. Request*
5. See request
6. Approve if it owns*

* Trigger server to send message

Proposed change with ownership and no conflict: automatically accepted and sync
Proposed change without ownership: workflow & ownership determine approval process
Conclusion

• We have prototyped a collaborative environment for DSN scheduling and successfully proved the concept
• DSN scheduling is a system that involves multiple agents
• Collaborative scheme needs to be developed in a multi-agent environment
• Efficient communication and data synchronization is a key for collaboration